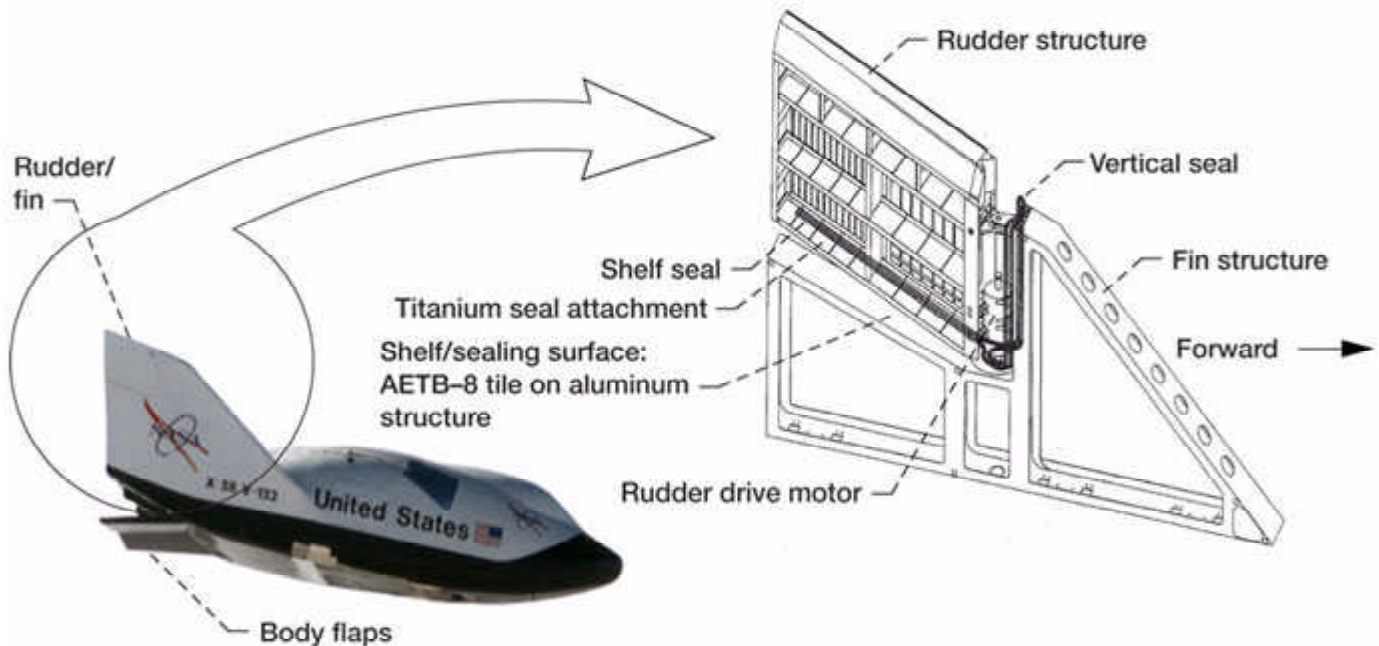


Rudder/Fin Seals Investigated for the X-38 Re-Entry Vehicle



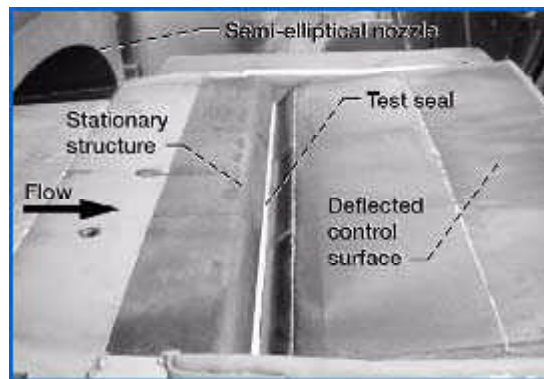
X-38 rudder/fin seal assembly with rudder/fin structure and seal locations. (AETB-8 is the shuttle tile material.)

NASA is developing the X-38 vehicle that will demonstrate the technologies required for a potential crew return vehicle for the International Space Station. This vehicle would serve both as an ambulance for medical emergencies and as an evacuation vehicle for the space station. Control surfaces on the X-38 (body flaps and rudder/fin assemblies) require high-temperature seals to limit hot gas ingestion and the transfer of heat to underlying low-temperature structures. Working with the NASA Johnson Space Center, the Seals Team at the NASA Glenn Research Center completed a series of tests to further characterize baseline seal designs for the rudder/fin interfaces of the X-38. The structures of the rudder/fin assembly and its associated seals are shown in the preceding illustration.

Tests performed at Glenn indicated that exposure of the seals in a compressed state at simulated seal re-entry temperatures resulted in a large permanent set and loss of seal resiliency. This could be of concern because the seals are required to maintain contact with the sealing surfaces while the vehicle goes through the maximum re-entry heating cycle to prevent hot gases from leaking past the seals and damaging interior low-temperature structures. To simulate conditions in which the seals may become unloaded during use, such as when they take on a large permanent set, Glenn researchers performed room-temperature flow and compression tests to determine seal flow rates, resiliency, and unit loads under minimal loads. Flow rates through an unloaded (i.e., 0-percent compression) double seal arrangement were twice those of a double seal compressed to the 20-percent

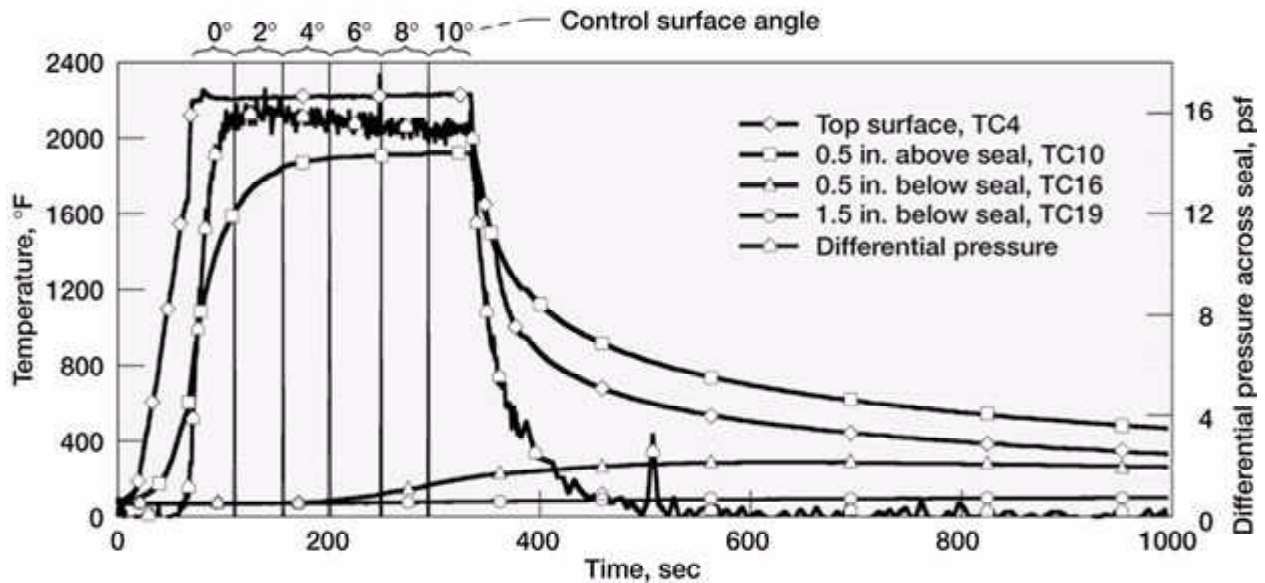
design compression level. These flow rates are being used in thermal analyses to predict the effect of flow through the seals on over-all seal temperatures. Compression test results showed that seal unit loads and contact pressures were below the limits that Johnson had set as goals for the seals. In the rudder/fin seal location, the seals are in contact with shuttle thermal tiles and are moved across the tiles as the rudder is rotated during re-entry. Low seal unit loads and contact pressures are required to limit the loads on these tiles and minimize any damage that the seals could cause.

A series of tests were performed on these seals in NASA Ames Research Center's arc jet facility. The arc jet facility approximates relevant thermal environments that a seal or other structure would be subjected to during extreme heating conditions such as those experienced during space vehicle re-entry. Eleven tests were completed, including one test in which no seal was installed in the gap to examine the flow of heat down into the gap. The seal was compressed between stationary insulation tiles and a movable elevon that was rotated during the test to deflect the arc jet exhaust into the seal gap (see the next figure). Peak seal temperatures as high as 2000 °F were reached during the 5-min tests (see the final figure). Results of these tests indicate satisfactory performance of the seal for single-use (e.g., X-38) applications. The results of these tests were shared with the NASA Johnson Space Center and are being used to validate aerothermostructural analysis codes that predict seal temperatures under these conditions.



Test fixture installed in arc jet tunnel with seal installed.

The tests performed at Glenn have provided valuable information to Johnson about the performance of the seals that they are considering using in the rudder/fin location of the X-38 vehicle. Glenn and Johnson are currently defining what additional work needs to be done to develop the final rudder/fin seal design for the X-38 vehicle.



Temperatures and pressure differential measured for arc jet test with seal installed at 20-percent compression (test 5). Table angle, 6°; control surface angles, 0°, 2°, 4°, 6°, 8°, and 10°; nominal gap, 0.25 in. (Note that symbols on graph are given for identification only; data were recorded every 1 sec. TC indicates a thermocouple.)

Find out more about this research:

Structural seals and thermal barriers: <http://www.grc.nasa.gov/WWW/structuralseal/>
 High-temperature, flexible, fiber preform seal:
http://www.grc.nasa.gov/WWW/structuralseal/InventYr/1996Inv_Yr.htm
 Glenn's Mechanical Components Branch <http://www.grc.nasa.gov/WWW/5900/5950/>

Bibliography

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Programs/Projects: X-38, ASTP/3rd Generation RLV, Advanced Control Surface Seals, Advanced Propulsion System Seals